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Multi-beamlet investigation of the deflection compensation methods of SPIDER beamlets

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The ITER experiment will be the first step towards energy from fusion. Nuclear reaction will occur in a hot (Te < 40keV) plasma requiring external heating systems like the injection of energetic beams of particles. In order to gain a better understanding of the physics of neutral beam injectors (NBI) and to optimize the prototype of ITER injectors, a dedicated test facility is under construction at Consorzio RFX, Padova (Italy). It will feature two major experiments: MITICA (Megavolt ITER Injector and Concept Advancement), a complete prototype of the ITER NBIs, and a full-scale ion source, named SPIDER (Source for Production of Ions of Deuterium Extracted from an Rf plasma). SPIDER is designed to extract and accelerate a $355\ A/m^2$ current of H^- (or $293\ A/m^2$ of D^-) up to 100 kV and its construction is entering the final phase, with most of the components already procured and the first beam expected by the end of 2016.
SPIDER accelerating stage is composed of three electrodes (plasma grid PG, extraction EG and grounded grid GG), each featuring 16 groups of 5x16 apertures tracing beamlet path. Two effects perturb the beamlet path during the acceleration stage: space charge repulsion and the deflection induced by the permanent magnets (CESM) embedded in the extraction grid, needed to suppress co-extracted electrons. These two effects have respectively electrostatic and magnetic origin and can be reduced by electrostatic or magnetic means. A unique feature of SPIDER experiment is the presence of different methods of compensation for the deflection induced by CESM: a magnetic one which make use of a second group of permanent magnets, embedded in the GG; and an electrostatic one which consists in offsetting the apertures of the GG, thus steering the beamlet in order to counteract the deflection.
The purpose of this work is to evaluate and compare benefits, collateral effects and limitations of electrical and magnetic compensation methods for beamlet deflection. The study of these methods has been carried out extensively by means of numerical modelling tools: multi beamlet simulations have been performed. This is a further step with respect to the earlier analyses on this ion source [1].
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[1]P.Agostinetti et Al., Physics and engineering design of the accelerator and electron dump for SPIDER, 28 april 2011, Nucl. Fusion 51 (2011) 063004 (16pp).